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## FOOT-AND-MOUTH DISEASE

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U. S. Department of Agriculture



**F**OOT-AND-MOUTH DISEASE is one of the most universal diseases of cattle, as well as one of the most difficult to suppress. Although essentially a disease of cattle, most other farm animals are susceptible in varying degrees.

Although not so malignant as some other animal diseases, it nevertheless has been known to cause serious losses. Its worst menace, however, consists in its extreme contagiousness, so that when it makes its appearance anywhere it is liable to spread with great rapidity in all directions where there is any movement of livestock. Not only so, but the infection may be carried by persons, dogs, birds, etc., and by infected hay, straw, or other materials coming in contact with susceptible animals. It is evident, therefore, that only the most prompt and radical measures are of any value in eradicating it.

In most European countries the disease has gained such a foothold that it has probably become a permanent infection.

The United States has suffered nine foot-and-mouth visitations, ranging in date from 1870 to 1929. Fortunately, after persistent efforts by the Government, the States, local authorities, and individual stockmen, each outbreak was entirely stamped out.

# FOOT-AND-MOUTH DISEASE

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## NATURE AND CHARACTERISTICS

Foot-and-mouth disease, also known as aphthous fever, epizootic apthia, and eczema contagiosa, is an acute, highly communicable disease chiefly confined to cloven-footed animals and characterized by an eruption of vesicles or blisters on the mucous membrane of the mouth and on the skin between the toes and above the hoofs. The vesicles rupture, forming erosions and ulcerations; there are also salivation, tenderness of the affected parts, loss of appetite, lameness, emaciation, and diminution in the quantity of milk secreted.

The tremendous ravages of the disease are seen in the number and variety of the species attacked. While it may be regarded as essentially a disease of cattle, hogs seem to be as easy a prey. Almost in the same grade of receptivity are goats and sheep. Next in order of susceptibility come the buffalo, American bison, camel, deer, chamois, llama, giraffe, and antelope. Horses, dogs, cats, and even poultry may occasionally become infected with the disease, the last three being particularly dangerous as carriers of the contagion. Man himself is not immune, and the frequency of his infection by coming in contact with diseased animals is established by numerous observations.

As in other communicable diseases the source and origin of foot-and-mouth disease have given rise to much speculation. The disease had been known in Europe for centuries, but it was not until comparatively recent years that the erroneous conceptions

of its spontaneous origin as a result of climatic and meteorological conditions, exhausting journeys, etc., were abandoned. It is now conceded that foot-and-mouth disease is propagated by a specific virus and that every outbreak starts from some preexisting outbreak.

Investigators have so far been unable to identify or isolate the specific organism causing the disease, although numerous attempts have been made to cultivate and stain it by laboratory methods. Experiments have shown that the virus will pass through standard germ-proof filters, thus indicating its minute size and the reason it has not been detected by the staining methods. The contagion may be found in the serum of the vesicles on the mouth, feet, and udder; in the saliva, milk, and various secretions and excretions; also in the blood during the rise of temperature.

A wide distribution of the virus and a rapid infection of a herd is the result. Animals may be infected directly, as by licking, and in calves by sucking, or indirectly by such things as infected manure, hay, utensils, drinking troughs, railway cars, animal markets, barnyards, and pastures. Human beings may carry the virus on their shoes and clothing and transmit it on their hands when milking, since the udder is occasionally the seat of the eruption. It may also be carried by dogs, cats, rats, chickens, pigeons, etc. Milk in a raw state may also transmit the disease to animals fed with it.

The observations made by some veterinarians would lead us to suppose

that the virus is quite readily destroyed. It is claimed that stables thoroughly cleaned become safe after drying for a short time. Hence, litter of all kinds, such as manure or soiled hay and straw, may remain infective for a longer time because they do not dry out. Other authorities maintain that the virus is quite tenacious and may live in stables even as long as a year. They also state that animals which have passed through the disease may be a source of infection for several months after recovery.

Unlike most other infectious diseases, foot-and-mouth disease may attack the same animals repeatedly. No definite immunity is conferred by an attack, though some animals are immune for a longer time than others.

The period of incubation (that is, the time elapsing between the exposure of an animal to infection and the development of the disease in that animal) is variable, usually from three to six days. The disease may appear in 24 hours, or, in exceptional cases, not for 18 days or even longer.

### LOSSES

The highly contagious character of foot-and-mouth disease and its rapid spread to practically all exposed susceptible animals lead to heavy losses. Since the mortality is comparatively low, ranging from only 3 per cent or less in mild forms to 30 or 40 per cent in malignant cases, the havoc caused by the pestilence is sometimes underestimated. But there are other sources of loss which are much more important than the actual mortality. The fever and the difficulty of eating cause a rapid and extreme loss in flesh and a lessening or cessation of the milk secretion. The udders often become inflamed and ruined by the formation of abscesses, and cows affected in this way are sometimes rendered permanently valueless for milk production. The inflammation of the feet may cause the horn to drop from the toes, producing great lameness and lasting injury. Abortion is frequent with pregnant animals, and typical lesions have been observed in the newly born at birth. Altogether these losses may amount to 20 or 30 per cent of the value of affected animals.

In addition there are indirect losses of a commercial nature. Dairy farmers are put out of business for a time. Necessary quarantine restrictions greatly interfere with the movement of livestock and such commodities as hay, straw, hides, and farm produce. The

business of the stockyards and slaughtering centers is greatly interfered with. Sometimes it is necessary to close stockyards for disinfection. The whole business of marketing, transporting, feeding, and slaughtering is interrupted and deranged. Losses of this character may reach enormous proportions.

### THE DISEASE IN OTHER COUNTRIES

Foot-and-mouth disease has prevailed in Europe for a great many years and has occasioned tremendous economic losses there. In most countries of continental Europe the plague has existed so long and has gained such a foothold that it is economically impossible to fight it with American methods of slaughter and disinfection, for to do so would be to kill a large percentage of the livestock of those countries. This likewise holds true in the case of many countries of South America and the Orient. In consequence, little or no progress toward eradication has been made.

An outbreak which appeared in Germany in 1888 increased steadily until 1892, when it diminished gradually for a few years, but the disease again reached great proportions in 1899. Thereafter it continued to a greater or less extent until in 1911 it attained a virulence previously unequaled, and approximately one out of seven of the susceptible animals was affected. The Government attempted to control outbreaks by slaughter of infected herds, but the pestilence had gained too much headway and was too firmly established in various portions of the country for this method to succeed, and it had to be abandoned. In portions of Germany the farmers, realizing that the disease is inevitable, make haste to be done with it by exposing their stock deliberately to mild cases in the hope that this will result in an immediate mild attack and immunity for several years thereafter. Such immunity, however, is very uncertain. As soon as an animal's period of acquired immunity is over and favorable conditions present themselves, the contagion breaks out with renewed virulence; consequently, it is found impossible to control it, much less to eradicate it by means of quarantines. One scientist has asserted that unless all the infected farms were absolutely isolated and the movement not only of livestock but of persons absolutely prohibited, the disease could not be stamped out. Such a quarantine would of course be utterly impossible to enforce in any country.

Great Britain and Norway on account of their comparatively isolated positions have been more successful in keeping out the disease. The outbreaks in those countries have been more sporadic and by resorting to immediate slaughter the authorities have been able to stamp them out. Sweden, though more directly exposed through proximity to continental Europe, was for many years likewise successful in the exercise of protective and eradication measures. However, in dealing with an outbreak in 1924, supposedly introduced from Denmark, the policy of slaughter was abandoned and that of segregation substituted. As a result the infection has apparently become firmly established in Sweden.

Great Britain has applied the combined quarantine and slaughter methods for many years, and sometimes has adopted measures which were even more stringent than any that have been used in the United States. A British official (Cope) asserted in 1899 that after his country's experience with the disease it was "more dreaded by the farmers and stock raisers of Great Britain than cattle plague or pleuropneumonia, and they are now willing and ready to put up with any restrictions, of however drastic a character, considered necessary by the central department to stamp it out."

For several years prior to 1910, Great Britain was practically free from the disease. Outbreaks occurred in every year from 1910 to 1916, however, and after freedom in 1917 there was a recurrence in 1918. Since that time the disease has been almost constantly present in one part of the United Kingdom or another.

The condition became serious in 1923, when there were 1,929 outbreaks in 43 counties and 128,785 animals were slaughtered in efforts at eradication. Also, in 1924, there were 1,515 outbreaks and 88,850 animals slaughtered. There was some slight improvement during subsequent years. Outbreaks, however, continued annually, and during the first 13 weeks of 1928 there were 87 outbreaks and 6,993 animals slaughtered.

Early in 1922 Scotland, for the first time since 1908, was invaded by the disease. Following prompt eradication, the country remained free until October, 1923, when another outbreak occurred, followed by others in 1924 and 1926. In 1926 the disease was apparently found in the carcasses of pigs imported from continental Europe.

In 1922 and 1923 the disease appeared on the Channel Islands but was promptly eradicated.

Ireland (Northern Ireland and the Irish Free State) has experienced visitations only at rare intervals, as in 1928, when there was an outbreak on the southeastern coast of the Irish Free State, which was eradicated without delay.

A British Government committee which was appointed in 1922 to investigate the situation and make recommendations reported that "in our view the principal causes which led to the outbreak becoming of such a widespread character were: (a) The delay in reporting disease in the initial case; (b) the contamination of railway loading docks, trucks, etc.; (c) the movement of animals after contact with infection in markets; (d) the rapid movement of animals, particularly steers, from market to market; (e) the delay in dealing with confirmed outbreaks of disease during the earlier stages of the outbreak; and (f) the movement of persons, vehicles, etc., from premises whereon outbreaks had occurred." On the question of methods of combating outbreaks the committee reported: "We are in agreement with the majority of witnesses who have stated their opinion that the policy of slaughter is the correct one and should be maintained."

In November, 1906, the disease reached Belgium from France and by the end of the year every province in Belgium was affected, also the Netherlands. Efforts to eradicate it from Belgium were unavailing. The Netherlands, apparently, succeeded in stamping it out for about six months, but it reappeared and cases have been reported for several years, including 1928.

The disease is also reported as being more or less prevalent in Austria, Czechoslovakia, Denmark, France, Hungary, Italy, Poland, Russia, Spain, Switzerland, and the Balkan countries. Australia and New Zealand have remained free from it.

There is less accurate information regarding Asia and Africa, but while Japan, the Union of South Africa, and many islands of the South Pacific are apparently free from the infection, it has been reported from India, Algeria, Tunisia, Morocco, Egypt, and the Sudan in Africa, and is known to be prevalent in China, the Philippines, and various islands of the East Indies. It is doubtful whether any considerable part of the Orient is free from it.

In South America the disease is reported as common in Brazil, Argentina, and Uruguay, and in some of the other countries of that continent. It appeared in Jamaica in the summer of 1922 and spread extensively over the island. It was not eradicated finally until 1927.

In 1926 there was an outbreak in the southeastern part of Mexico, which in December, 1927, was officially declared to be eradicated.

Canada has been fortunate in maintaining freedom from the disease for many years.

### OUTBREAKS IN THE UNITED STATES

Foot-and-mouth disease has appeared in the United States on several occasions—1870, 1880, 1884, 1902, 1908, 1914, 1924 (twice), and 1929.

The first outbreak in 1870 was introduced by way of Canada, where the infection was brought by an importation of cattle from Scotland. It spread into the New England States and New York and appears to have been arrested within a few months. Its failure to spread more extensively and its early disappearance have been ascribed to favorable conditions, such as the movement of livestock from west to east, the limited trading at that period as compared with the present time, the restriction of traffic by winter weather, and the infrequency of travel which obtained at that time among people.

About 1880 there were two or three lots of animals brought to the United States affected with the disease, but there was no extension from the animals originally affected.

In 1884 there was a small outbreak at Portland, Me., caused by imported cattle, and the disease spread to a few herds outside of the quarantine station. Owing to the small number of animals affected and the limited area of territory covered by the disease, it was easily brought under control.

It will be observed that in all these early outbreaks the contagion was introduced with imported animals. Since the development of a stringent system of inspection and quarantine of imported livestock no instance of that kind has occurred. On subsequent occasions the infection has evidently been brought in with contaminated products or materials and not by means of live animals.

In November, 1902, the disease was discovered in Massachusetts and Rhode Island. The earliest cases were traced to Chelsea, Mass., near the docks, and it was suspected for a time that the

infection was brought in with foreign shipping, by some such means as hay, straw, halters, ropes, hides, hair, wool, etc. Later developments, however, and especially investigations into the cause of the 1908 outbreak, led to the belief that a more probable source of the infection was cowpox vaccine virus imported from a country where foot-and-mouth disease existed (probably Japan), the vaccine virus being contaminated with the virus of foot-and-mouth disease.

A Federal quarantine was declared by the Secretary of Agriculture on November 27, 1902, as soon as the nature of the disease was established, and steps for eradication were at once taken by the Bureau of Animal Industry of the United States Department of Agriculture in cooperation with authorities of the affected States. The methods followed consisted of inspection to trace and detect the disease, quarantine of infected premises and territory, slaughter and burial or burning of diseased and exposed animals, and disinfection of premises.

This outbreak involved Massachusetts, New Hampshire, Vermont, and Rhode Island. It was eradicated in about six months. There were found infected 244 herds including 4,712 cattle. Of these, 205 herds with 3,872 cattle, as well as 360 hogs and 229 sheep and goats, were slaughtered. The cattle infected but not slaughtered were those that either died or completely recovered before slaughtering could be carried out. The animals slaughtered were valued at \$184,155.10, and the Federal Government reimbursed owners to the extent of 70 per cent, or \$128,908.57. It is understood that the States paid the remainder. The total cost to the Department of Agriculture of stamping out the disease was about \$300,000.<sup>1</sup>

The next appearance of foot-and-mouth disease was early in November, 1908, when it was observed in cattle near Danville, Pa. A Federal quarantine was issued November 12. The infection was traced back to the stockyards at East Buffalo, N. Y., and to Detroit, Mich. The disease appeared in the States of Michigan, New York, Pennsylvania, and Maryland. A careful and thorough investigation made by the writer in conjunction with M. J. Rosenau, of the Public Health Service, demonstrated that the outbreak started from calves used to propagate vaccine

<sup>1</sup> A history of the outbreak of 1902-3 appears in the Nineteenth Annual Report of the Bureau of Animal Industry (for 1902), page 391.

virus at an establishment near Detroit, and that the source of the infection was contaminated Japanese vaccine virus.<sup>2</sup>

Vigorous measures of eradication similar to those employed in 1902-3 were at once put into effect and the disease was stamped out in about five months at an expense to the Department of Agriculture of about \$300,000 and to the States of about \$113,000. The inspectors made 108,683 visits to farms, stockyards, etc., and inspected more than 1,500,000 animals (including reinspections). One hundred and fifty-seven premises were found infected, and 3,636 animals (2,025 cattle, 1,329 hogs, and 282 sheep and goats), valued at \$90,033.18, were slaughtered. Owners were reimbursed for the value of their animals and property destroyed, one-third being paid by the States and two-thirds by the Federal Government.

Another outbreak was discovered in the vicinity of Niles, Mich., in October, 1914, after it had evidently been under way since August of that year. A campaign to check the spread of the disease and to stamp it out was immediately begun by the United States Department of Agriculture in cooperation with the State authorities. The first Federal quarantine was issued October 19, 1914. The outbreak turned out to be the most serious and extensive ever known in this country, the last infection not being disposed of until May, 1916. It spread into 22 States and the District of Columbia. The affected States were New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, Ohio, Michigan, Indiana, Kentucky, Wisconsin, Illinois, Minnesota, Iowa, Kansas, Montana, and Washington. The Middle Western and Eastern States were mostly affected. The chief sufferer was Illinois, more than one-third of the total losses having occurred there. The Union Stock Yards at Chicago became infected early and were a source of dissemination of the contagion in all directions. These yards and others found

infected were closed temporarily and disinfected. The methods of eradication in general were the same as in the two preceding outbreaks, namely, quarantine, inspection, slaughter of diseased and exposed animals, and disinfection of premises.

In round figures the total number of animals slaughtered in the outbreak was 172,000, comprising 77,000 cattle, 85,000 swine, and 10,000 sheep, and including 114 goats and 9 deer. The appraised value of these animals was approximately \$5,860,000, half of this expense being borne by the Federal Government and half by the several States involved. Other expenses brought the total Government expenditures to about \$4,600,000. Adding the quotas expended by the States, the entire cost of eradicating the outbreak amounted to about \$9,000,000.<sup>3</sup>

In February, 1924, foot-and-mouth disease was discovered in California, its first appearance having been noted in two herds of dairy cattle near Oakland. The source of the infection was unknown, but it is believed that it came from the Orient, as the disease was traced to hogs fed on garbage from ships. Eradication was promptly undertaken by Federal and State forces by methods followed in previous outbreaks. Some unusual difficulties were encountered in the spread of the disease to large range herds and flocks in rough, inaccessible, poorly fenced country and to deer in a national forest. The disease extended to 16 counties in California, and was eradicated in 10 months. There was some recurrence of the disease, however, during the next year, and the last cases were disposed of by June 10, 1925.

Before the California outbreak had been suppressed the disease also appeared in Texas late in September, 1924, in a herd of Zebu cattle south of Houston. Investigation showed that the infection probably entered through a port on the Gulf of Mexico, there being no apparent connection with the outbreak in California. The Texas outbreak, affecting two counties, was apparently suppressed within 30 days by the usual vigorous measures, but nearly a year later, in July, 1925, the disease reappeared on the same premises where it had first been found. Eradication was completed in October.

The animals slaughtered in eradicating the California and Texas outbreaks

<sup>2</sup> A report of this investigation was published as Bureau of Animal Industry Circular 147. A history of the 1908 outbreak was given in the Twenty-fifth Annual Report of the Bureau of Animal Industry (for that year), page 379. It may be remarked that the importation and the domestic manufacture of vaccines and other biological products are now under Government supervision, those intended for use in human medicine being looked after by the Public Health Service and those for veterinary use by the Bureau of Animal Industry.

<sup>3</sup> A full report of this outbreak may be found in United States Department of Agriculture Circular No. 325, Foot-and-Mouth Disease, with Special Reference to the Outbreak of 1914.



were as follows: In California, 58,791 cattle, 28,382 sheep, 21,195 swine, 1,391 goats, and 22,214 deer, making a total of 131,973 animals. In Texas, 29,323 cattle, 1,429 sheep, 821 swine, and 345 goats; total, 31,918 animals. The appraised value of animals and property destroyed in these outbreaks was more than \$5,000,000.<sup>4</sup>

The latest outbreak occurred in southern California in 1929, under much the same conditions as the preceding California outbreak of 1924. A positive diagnosis of foot-and-mouth

miles distant from the original outbreak, and three days later another herd of cattle in the same vicinity as the second one was found to be affected. Rigorous search disclosed no further infection until on February 6 the disease again appeared 6½ miles to the south, and 10 days later the infection was found on another farm a few miles away. The 1929 outbreak was confined to the five premises mentioned, but 28 additional contact herds were also destroyed as a precautionary measure. Quarantine was removed from the affected area on March 18.

The total number of animals slaughtered in the outbreak was 3,591, comprising 277 cattle, 3,291 swine, and 23 goats. The appraised value of the animals and of the property destroyed in disinfecting the premises was \$109,958.

### SYMPTOMS

In three to six days, or even longer, after the exposure of the animal to the infection the disease makes its appearance. It is usually first indicated by the animal suffering from a chill, quickly followed by an invasion of fever, which may cause the temperature to rise as high as 106° F. These symptoms are not always present, or may be in so slight a form as to escape

notice. Following this in one or two days it will be noticed that small vesicles or blisters about the size of hempseeds or peas are making their appearance on the mucous membranes of the mouth at the border and upper surface of the tongue, near the tip, the inside of the cheeks, on the gums and the inner surface of the lips, or on the margin of the dental pad. These little blisters contain a yellowish, watery fluid and gradually become more extensive as the disease advances. Soon after the eruptions have appeared in the mouth of the animal it will be noticed that there is considerable swelling, redness, and tenderness manifest about the feet, at the coronet, and between the digits of each foot. Eruptions similar to those within the mouth



FIGURE 1.—Lesions of foot-and-mouth disease on tongue of cow

disease was reported on January 18 from a large herd of garbage-fed swine near Whittier, in Los Angeles County. The source of the infection was traced to garbage from a trading steamship which had recently docked at San Pedro after being supplied with fresh meat at a South American port. Federal and State quarantines were at once put into effect and the herd of swine was slaughtered and buried on January 19.

On January 30 the infection broke out in a herd of cattle about 8

<sup>4</sup>A complete report of this outbreak was published in U. S. Department of Agriculture Circular No. 400, Foot-and-Mouth Disease, with Special Reference to the Outbreaks in California, 1924, and Texas, 1924 and 1925.

(fig. 1) make their appearance on these swollen regions of the foot (fig. 2) a day or two later, and at this stage it is usual to find that like lesions have made their appearance on the perineum of the victim. In the case of milk cows, the udder, and more particularly the teats (fig. 3), show the same vesicular eruption, but the latter as the result of milking soon become covered with reddened spots deprived of the superficial layer of skin and may develop deep, obstinate fissures.

As soon as the disease has become well established the patient evinces pain when attempting to eat; in fact the appetite is often so seriously affected that all feed is refused and the animal uneasily opens and shuts its mouth with a characteristic smacking sound, while strings of cohesive, ropy saliva hang suspended from the lips. With the advance of the disease the vesicles have widened and extended until they may reach a diameter ranging from that of a dime to that of a silver dollar. These rupture soon after their appearance, sometimes on the first day, more rarely on the second or third day. After they have ruptured, the grayish white membrane forming the blister may remain attached for a day or more, or disappear speedily and leave deeply reddened sensitive spots or erosions, both within the mouth and upon the coronet and between the claws of the feet. Similar erosions, which quickly form scabs as a rule, may be noticed in cases in which the teats of milk cows have become affected, and instances are reported in which sloughing of the tegument immediately around the lesions on the udder has occurred. Owing to the tough, fibrous nature of the bovine skin, it is exceedingly rare for sloughing to occur on any part of the body other than those mentioned.

The attack upon the feet of an animal is frequently manifested in all four feet at once, but one or more of the feet may entirely escape and remain unaffected throughout the course of the disease. The ulceration of the interdigital tissue may extend to the ligaments of the fetlock or produce disease of the joint or bone. As the feet become sensitive and sore the animal lies down persistently, and it has been found that bedsores develop with amazing rapidity in all such cases and wholly baffle all attempts at treatment until after the patient has regained its feet.

The disease may attack some of the internal organs before it appears on

any of the external tissues. These cases are very liable to prove quickly fatal. The animal dies from paralysis of the heart, due to formation of poisonous substances within the system, or it may suffocate by reason of the action of these same poisons on the tissues of the lungs, or it may choke to death as a result of paralysis of the throat.

In cases of serious affection of the udder the erosions will often be found located within the passages of the teats, resulting in a "caked" udder, and the same toxic poisoning which is the cause of death in the apoplectic form types just mentioned may arise from this source. In any event, the milk from such cases will be found dangerous for use, causing fatal diarrhea in sucking calves or young pigs and serious illness in human consumers. The milk obtained from cows suffering with



FIGURE 2.—Foot lesions of foot-and-mouth disease

foot-and-mouth disease is not readily converted into either butter or cheese but remains thick, slimy, and inert in spite of churning and attempts at curdling. Pregnant animals may abort. In pigs, sheep, and goats the lesions in the foot are most common, but both forms may be observed or only the mouth lesions.

When the disease has become fully established it will be found that the duration of the attack will vary greatly with different animals. From 10 to 20 days are usually required for the recovery of the normal appetite and splits in mild outbreaks, while the return to a full flow of milk, in the case of milk cows, is seldom witnessed before the arrival of the following season.

In the malignant type of the disease it requires from three months to a year for an animal to recover. The mor-

tality, as already stated, is usually low. The disease is more fatal in young animals that have been fed on infected milk, and produces death in from 60 to 80 per cent of these cases as a result of gastroenteritis. In the 1914 outbreak numerous new centers of infection were started among hogs and calves which had been fed on unpasteurized, infected milk from creameries.

### DIAGNOSIS

This recognition of this affection should not, as a rule, be difficult when the disease is known to be in the vicinity. The combination of high fever, vesicular inflammation of the mouth, and hot, painful, swollen condition of the feet, followed 24 to 48 hours later

### HOW TO DISTINGUISH FOOT-AND-MOUTH DISEASE FROM OTHER AFFECTIONS

The disease which may be most readily confounded with foot-and-mouth disease is vesicular stomatitis of horses and cattle, and experience has shown that a prompt and exact differentiation is accompanied with numerous difficulties. The drooling, vesicles, and erosions are quite similar in appearance to those produced by foot-and-mouth disease, but in none of the animals examined in the field has there been found in vesicular stomatitis any soreness of the feet, which is a common symptom of foot-and-mouth disease. Moreover, many horses have vesicular stomatitis, but horses have not been observed to contract foot-and-mouth disease in any of the previous

foot-and-mouth outbreaks in the United States. Hundreds of hogs exposed to vesicular stomatitis and in association with the sick animals in pastures have shown no signs of the malady, and this is regarded as significant, because hogs generally are as susceptible to foot-and-mouth disease as cattle. Exposed sheep also fail to show vesicular stomatitis, yet these cloven-footed animals are susceptible to foot-and-mouth infection. In a number of cases of vesicular stomatitis the lesions appeared to be continuous or progressive and less simultaneous than in foot-and-mouth disease.

In these instances, secondary lesions were apparent on a number of consecutive days in the mouths of both horses and cattle, and vesicles were observed on the bases of tongues whose free portions were almost denuded of mucous membrane as a result of the rupture of similar vesicles six or seven days before.

Complications are extremely rare in vesicular stomatitis, and either chronic diseases of the hoof nor mammitis have been observed following it. Sucking calves are seldom affected with the disease, and rarely in other than a mild form, while an attack of foot-and-mouth disease in calves is always serious and not infrequently fatal. The vesicles in foot-and-mouth disease as a rule are larger than in vesicular stomatitis, and are more tightly filled with serous fluid. Furthermore, in-



FIGURE 3.—Blisters and scabs of foot-and-mouth disease on teets

by the appearance of numerous blisters varying in size from that of a pea to that of a walnut on the udder and feet and in the mouth should prevent any serious or long-continued error in the diagnosis. When the blisters have ruptured, however, and the resulting lesions have become contaminated by numerous secondary forms of microorganisms, the correct recognition of the disease may be involved in considerable difficulty. Nevertheless in the inoculation of calves and horses we have a certain and final test. In 24 to 96 hours after inoculation the calves present the characteristic blisters, while the horses, in our experience, will remain unaffected. Such inoculation, however, should be practiced only by officials who are properly authorized to deal with contagious diseases.

stead of increasing in virulence by passage through a series of calves, as foot-and-mouth disease has always done in our previous experiments, vesicular stomatitis became greatly reduced in virulence and required a constantly increasing period of incubation before manifesting lesions of the disease. Although numerous filtrate experiments have been conducted, in no case has the disease been reproduced in this manner, which is also unlike our experiments with foot-and-mouth disease.

The percentage of animals infected in each of the herds of cattle, and the history of exposure without transmis-

become turbid. The inoculation test in the case of cowpox does not respond with fever and eruption for at least 10 days, and often longer.

Necrotic stomatitis (sore mouth due to a germ) may be distinguished from foot-and-mouth disease by the fact that in the latter disease there is a rapid infection of the entire herd, including the adult cattle, as well as the infection of hogs and sheep. The characteristic lesion of foot-and-mouth disease is the appearance of blisters containing a serous fluid on the mucous membrane of the mouth and the udder, teats, and feet of the affected animals. In



FIGURE 4.—Inspectors examining cow for foot-and-mouth disease. They are equipped with rubber coats, gloves, boots, and hats, which are cleansed with disinfectants after each examination, in order to avoid spreading the contagion

sion of the disease except by immediate contact, would indicate that this ailment is not the highly contagious foot-and-mouth disease, which, once it is introduced into a herd, quickly affects practically 100 per cent of the cattle and hogs on all the farms to which the virus may be carried by intermediate agencies.

Cowpox or horsepox may be accidentally transmitted by inoculation. But the eruption of the "pox" goes on to the development of a pustule, whereas in foot-and-mouth disease the eruption is never more than a vesicle, even though the contained fluid may

necrotic stomatitis blisters are never formed, destruction of the tissues occurring from the beginning and being followed by the formation of yellowish, cheesy patches principally found involving the lining membrane of the mouth, especially the tongue and cheeks.

In mycotic stomatitis (sore mouth due to a fungus or mold), portions of the lining membrane of the mouth become inflamed and in a few days it changes to a croupous membrane which peels off, leaving a raw surface, while the thin skin between the toes may also be inflamed. The previous

history of the case; the failure of the blisters, if any appear, to spread extensively; the absence of vesicular eruptions on other portions of the body, notably the udder and teats, and characteristically, the foot, together with the absence of rapid spread to practically all cattle in the herd and the complete negative character of inoculation of calves, distinguishes between the local disease named and foot-and-mouth disease. Mycotic stomatitis occurs in only from 10 to 50 per cent of the animals in a herd, usually in the late summer or early fall after a dry spell, and it does not run a regular course.

The lesion resulting from ergotism may be distinguished from those of foot-and-mouth disease by the lack of eruptions in the mouth and by the location of the disease at the tips of the ears, end of the tail, or on the lower part of the legs, usually below the knees or hocks. The lesion of ergotism does not take the form of pustules or blisters, but manifests itself first as a swelling about the ankle, which later may slough and circumscribe the limb, forming a deep crack, extending entirely around the limb and forming a distinct line of demarcation between the healthy skin above and the diseased below. The absence of ulcerous sores on the coronet and between the claws, together with the healthy condition of the membranes of the mouth and the knowledge that the lesion on the limb in question extends uninterruptedly around it, should point conclusively to a diagnosis of ergotism and to the exclusion of all fears of foot-and-mouth disease.

In foul foot or ground itch of cattle, the inflammation of the skin and toes is general and not in certain spots, as in foot-and-mouth disease; the mouth remains unaffected and the presence of the disease may be traced to filth and poor drainage.

The severer forms of foot-and-mouth disease may be confounded with certain general diseases. Where gastrointestinal symptoms predominate acute gastric catarrh or inflammation of the intestines might be thought of. Involvement of the lungs might lead to a diagnosis of acute congestion of the lungs or pneumonia. This distinction is apparent in these diseases by the lack of vesicular eruption on the mucous membrane, or skin, and also by lack of evidences of infection in the herd or in neighboring animals.

## PREVENTION AND ERADICATION

The measures to be adopted to prevent the spread of the affection must take into consideration the highly infectious nature of the disease, its ease of dissemination, and the liability of the virus to live outside of the body of an animal for long periods. Great care should therefore be observed in keeping healthy animals unexposed to the contagion. When an outbreak occurs in a community, the owner should make every effort to keep other animals from coming in contact with his diseased cattle. This especially applies to dogs, cats, goats, and poultry, which usually have access to the stables and barnyards and in this way furnish excellent means for disseminating the infectious principle. He should be equally particular in prohibiting any person from entering his premises, especially an attendant or owner or other person in any way connected with livestock. Such a herd may be placed under quarantine, with an inspector appointed to keep the premises under constant surveillance.

This method of quarantine alone, although very satisfactory in many instances, is rather tardy in obtaining the desired results. The experience of European governments, already mentioned, shows that eradication by this method alone, when the disease has obtained a foothold, is practically impossible. For this reason when the disease breaks out in a country like the United States, where the contagion is liable to spread rapidly by means of infected cars, manure, hay, and other feed, and where the results of its obtaining a firm foothold would be so disastrous, it seems that this method of temporizing is inadequate, and more radical steps are required in order to suppress and eradicate completely the infection in the quickest and most thorough manner possible.

It therefore is deemed better to concentrate the expense incident to the extermination of foot-and-mouth disease by purchasing and slaughtering all affected and exposed animals susceptible to the disease, after judicious appraisal. The carcasses of these animals should be totally destroyed, preferably by cremation, or by burying them in a hole 6 feet deep and covering them with air-slaked lime (figs. 5 and 6). The infected stable should be disinfected by thoroughly cleaning it, scrubbing the floor with hot water,

brushing down all loose dust from the walls, and tearing off all woodwork which is partially decayed (fig. 7). Then the whole interior of the stable should be disinfected with one of the following disinfectants:

Chloride of lime, U. S. P. strength (30 per cent available chlorine), 1 pound to 3 gallons of water.

Caustic soda (94 to 96 per cent sodium hydroxide)  $1\frac{1}{4}$  pounds, hydrated lime 6 pounds to 10 gallons of water.

Formaldehyde, 1 quart 40 per cent solution to 5 gallons of water.

A 3 per cent solution of cresol compound, U. S. P., or accepted substitute

the United States, Denmark, Great Britain, and a few other countries, demonstrates in a striking manner the efficacy of slaughtering and the futility of relying upon quarantine alone in stamping out the disease.

Inoculation has been adopted in some countries in order to have the disease spread quickly through the herds, and although this practice has undoubtedly value where the disease is indigenous, it is not desirable in this country and should not be adopted.

Medical treatment with a view to curing affected animals is not to be recommended under conditions prevailing in the United States, where the



FIGURE 5.—Method of slaughtering and burying cattle. The trench is deep enough to allow carcasses to be covered with at least 5 feet of dirt. Animals are led into the trench and there killed, usually by shooting. Hides are slashed to prevent anyone from exhuming carcasses in order to get the hides, and carcasses are cut open and covered with quicklime

therefor, containing at least 50 per cent cresylic acid.

All stable utensils should be thoroughly cleaned and disinfected by the application of a solution of one of the above disinfectants. The manure should be burned or disinfected and spread over ground (other than meadow land) that is to be turned under. No other cattle should be purchased for at least 60 days after the complete disinfection of the premises.

The success in eradicating the disease by combined quarantine, slaughter, and disinfection, as practiced in

disease has not become established, and the first object is to stamp it out as quickly as possible. Even though most animals would recover with or without treatment, it would be practically impossible, while they were being held for recovery, to prevent the spread of the infection to others. The disease would be liable to spread faster than it could be cured. As already pointed out, it has been found impossible to prevent absolutely the spread of the contagion by the strictest quarantine alone, under the usual farm conditions. In addition, the affected

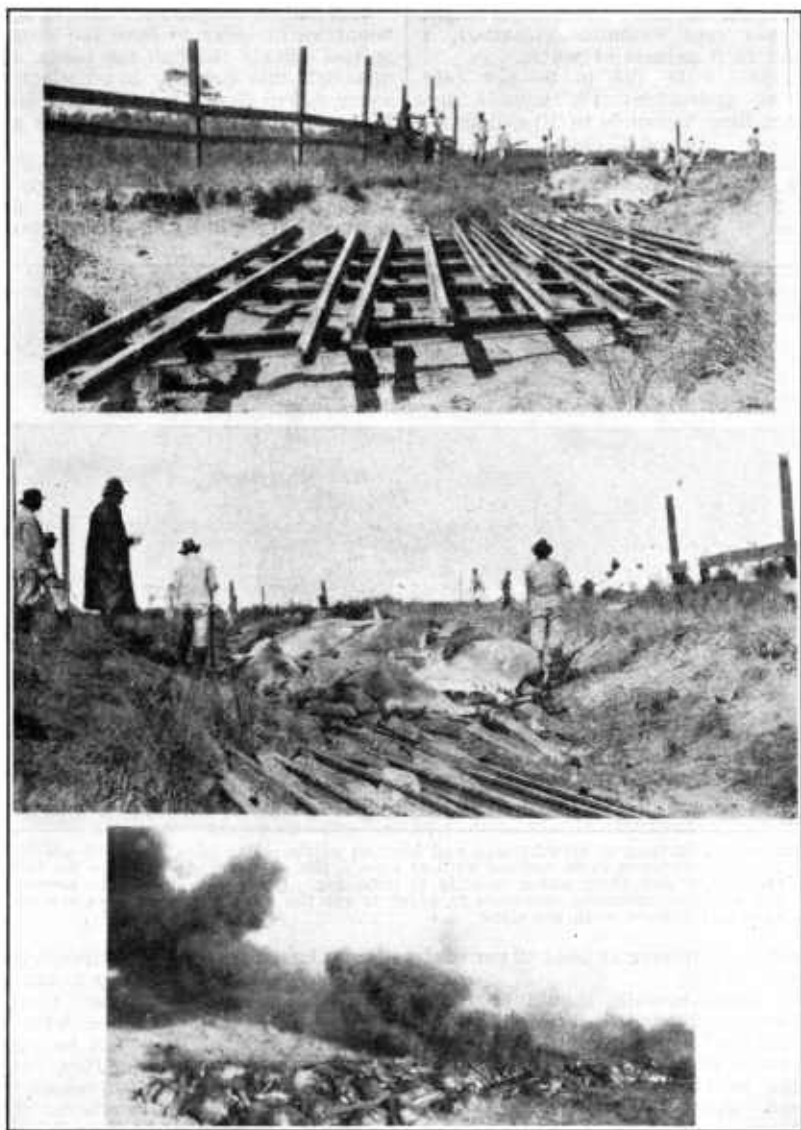


FIGURE 6.—Steps in destroying carcasses by incineration. *Top*—Network of steel rails, forming a grill. *Center*—Making preparations for burning carcasses. *Bottom*—Incineration in progress. Wood and crude oil are the fuels commonly used

animals that have passed through the disease may become a source of further infection as virus carriers for weeks and months after they have apparently recovered, and are susceptible of reinfection, as one attack does not confer permanent immunity.

### FOOT-AND-MOUTH DISEASE IN MAN

Foot-and-mouth disease is primarily and principally a disease of cattle, swine, goats, and sheep; secondarily and casually, a disease of man. It is transmissible to man through the eating or drinking of raw milk, butter-milk, butter, cheese, or whey from animals suffering from foot-and-mouth dis-

infected through contact with the diseased parts or by milking, slaughtering, or caring for the animals.

The symptoms in man resemble those observed in animals. There is fever, sometimes vomiting, painful swallowing, heat, and dryness of the mouth, followed by an eruption of vesicles on the mucous membrane of the mouth, and very rarely by similar ones on the fingers. The vesicles appear on the lips, gums, cheek, and edge of the tongue, and are about the size of a pea. The vesicles soon rupture, leaving a small erosion, which is soon covered by a thin crust, under which the new formation of epithelium proceeds rapidly. The skin eruption mostly ap-

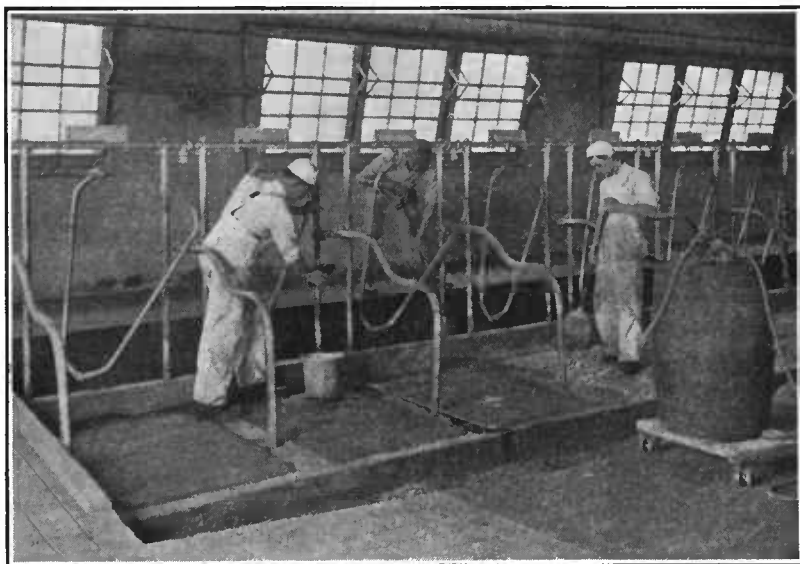


FIGURE 7.—Cleaning a stable in preparation for its disinfection. Thorough cleaning is an essential first step in order that the disinfectants may be sure to reach the germs or virus to be destroyed

ease. It is also transmitted directly, though more rarely, from the salivary secretions or other infected material which may gain entrance through the mucous membrane of the mouth. It is doubtful whether the disease can be transmitted to man by cutaneous or subcutaneous inoculation, though it is probable that the infection may be communicated if the virus directly enters the blood through wounds of any kind. Children are not infrequently infected by drinking unboiled or unpasteurized milk during the periods in which the disease is prevalent in the neighborhood, while persons in charge of diseased animals may become

pears on the hands, tips of the fingers, bases of the nails, and more seldom on the toes and other parts of the body. Besides these local changes, during the course of the disease there are occasionally observed headache, pain in the limbs, vertigo, abdominal cramps, vomiting, diarrhea, and weakness. The disease is very rarely fatal, usually appearing in a very mild form except in weakened children, in whom an accompanying intestinal catarrh may lead to a fatal termination.

Veterinarians who have had considerable experience with the disease among animals regard the human infection as by no means uncommon in



countries where foot-and-mouth disease prevails, but the disturbance of health is usually too slight to come to the notice of the family physician.

But few outbreaks of the disease have occurred in the United States, and therefore cases of its transmission to man in this country are quite rare. James Law reports having observed the disease in man from drinking infected milk during the epizootic of 1870 in the Eastern States, but the outbreaks of 1880 and 1884 affected such a small number of animals and were so quickly suppressed that no instance of its transmission to man was recorded. A few cases have been

reported by Brush accompanying the New England outbreak of 1902. Similar reports have been likewise received concerning the appearance of vesicular eruptions in the mouths of children during the 1908 and 1914 outbreaks, and the history of these cases incriminates the milk supply.

Experiments by Loeffler and Froesch, as well as other experiments in Denmark and Germany, indicate that the infection is comparatively easy to destroy by heat or the usual antiseptics. Milk pasteurized at a temperature of 60° C. (140° F.) for 20 minutes is safe so far as infection by foot-and-mouth disease is concerned.